Multilayer Ceramic Capacitors - Performance Characteristics

The EIA Standard for ceramic dielectric capacitors (RS-198C) divides into three classes.
CDE multilayer ceramic capacitors are available in the three most popular temperature characteristics:

COG: Class I (Also known as 'NPO')
Temperature Compensating capacitors, suitable for resonant circuits where stable capacitance and high Q are necessary. They are made of non ferro-electric materials yielding superior stability and low volumetric efficiency.

X7R: Class II
Stable capacitors, made of ferro-electric materials, yielding higher volumetric efficiency but less stability. These capacitors are suitable for by-pass or coupling applications where stability and Q are not a major factor.

Z5U: Class III
General Purpose capacitors, suitable for bypass coupling where dielectric losses, high insulation resistance and stability are not required. Made of ferro-electric materials, Class III capacitors have the lowest stability, but the highest volumetric efficiency.

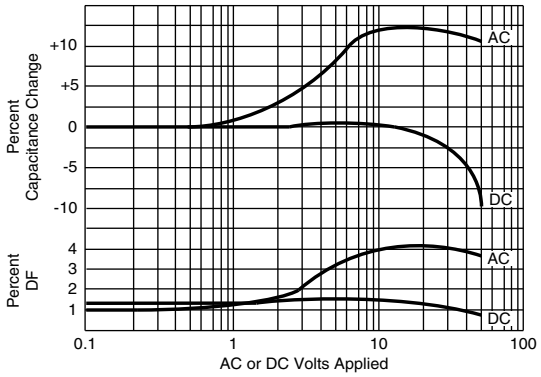
Parameter	COG (NPO)	X7R	Z5U
Temperature Characteristics:			
Range, ºC:	-55ºC to +125ºC	-55°C to +125ºC	+10ºC to +85ºC
Capacitance change without DC voltage:	0 ±30 PPM/ºC *	±15 %	+22 %, -56 %
Aging Rate: %ΔC / Decade Hour, Maximum:	0 %	2.5 %	5.0 %
Dissipation Factor:			
Test Conditions @ 25ºC:	>1000 pF w/1.0 vrms @ 1 kHz. ≤1000 pF w/1.0 vrms @ 1 MHz.	w/ 1.0 vrms @ 1 kHz.	w/ 0.5 vrms @ 1 kHz.
Limits:	0.15 % Max.	2.5 % Max.	3.0 % Max..
Insulation Resistance (IR):			
At rated voltage, whichever is smaller:	1000 megohms x µF or 100 gigaohms	1000 megohms x µF or 100 gigaohms	1000 megohms x µF or 10 gigaohms
Moisture Resistance: EIA RS-198C, Method B2, Condition A (10 cycles without applied voltage)			
Post test limits @ 25ºC, whichever is smaller:	100 megohms x µF or 10 gigaohms	100 megohms x µF or 10 gigaohms	100 megohms x µF or 1 gigaohm
Immersion Cycling: EIA RS-198C Method D2, Condition A (2 cycles @ 15 minutes each. Each cycle consists of immersion in hot bath @ 65ºC followed by immersion in cold tap water.)			
Post test limits @ 25ºC :			
Insulation Resistance, whichever is smaller:	100 megohms x µF or 10 gigaohms	100 megohms x µF or 10 gigaohms	100 megohms x µF or 1 gigaohm
Life Test: - 1000 Hrs.			
Test Potential and Temperature:	200 % V @ 125ºC	200 % V @ 125ºC	150 % V @ 85ºC
Post test limits @ 25ºC:			
Capacitance Change, whichever is greater:	±2% or 0.5pF	±20% of initial value**	±30 % of initial value**
Dissipation Factor:	0.25 % Max.	3.0 % Max.	4.0 % Max.
Insulation Resistance, whichever is smaller:	100 megohms x µF or 10 gigaohms	100 megohms x µF or 10 gigaohms	100 megohms x µF or 1 gigaohm
Dielectric Strength 2.5 times rated voltage with current limited to 50 mA.			

* 60 PPM!C below 10pF nominal.
+53 PPM -30 PPM/ºC from +25ºC to -55ºC comparable to MIL-C-20

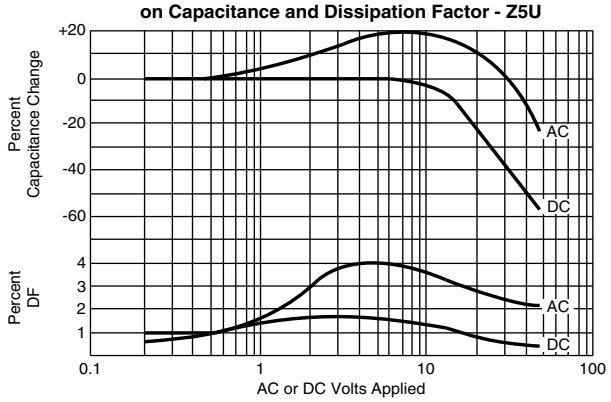
** X7R and Z5U dielectrics exhibit aging characteristics; therefore, it is highly recommended that capacitors be de-aged for 2 hours @ 150ºC and stabilized at room temperature for 48 hours before capacitor measurements are made.

Effect of Applied Voltage

Typical Effect of 1000 Hz AC and DC Voltage Level on Capacitance and Dissipation Factor - X7R

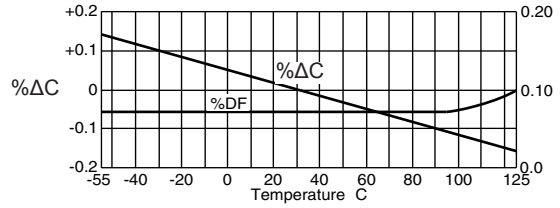


Typical Effect of 1000 Hz AC and DC Voltage Level on Capacitance and Dissipation Factor - Z5U

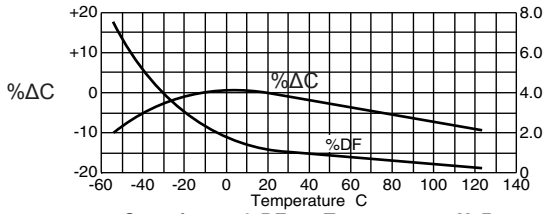


Note: COG Dielectric capacitance and dissipation factor are stable with voltage

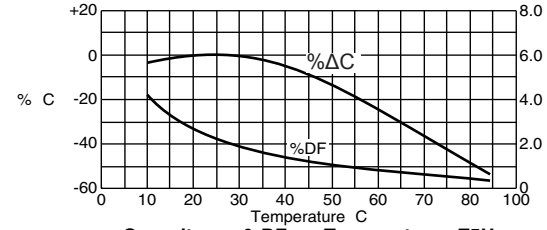
Effect of Temperature



Capacitance & DF vs. Temperature - COG

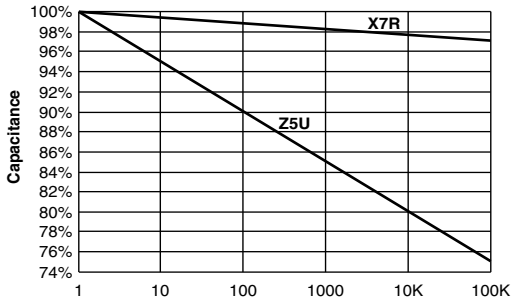


Capacitance & DF vs. Temperature - X7R



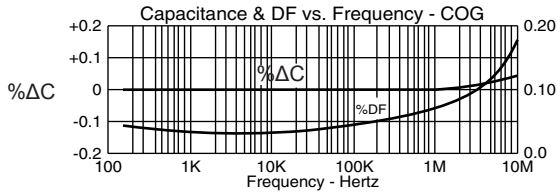
Capacitance & DF vs. Temperature - Z5U

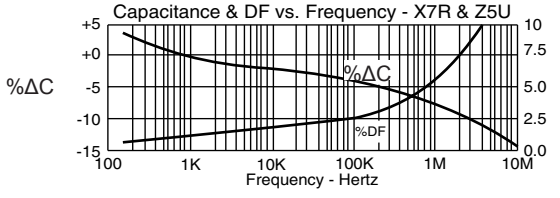
Effect of Time



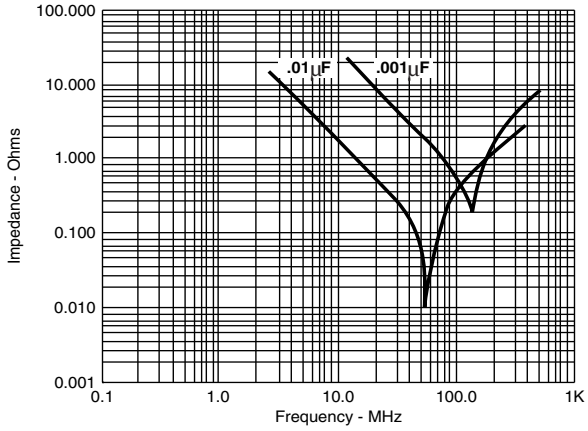
Typical Aging Rates for X7R and Z5U

Effect of Frequency

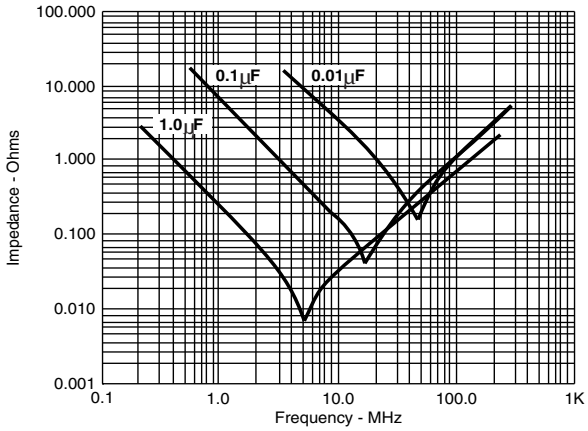




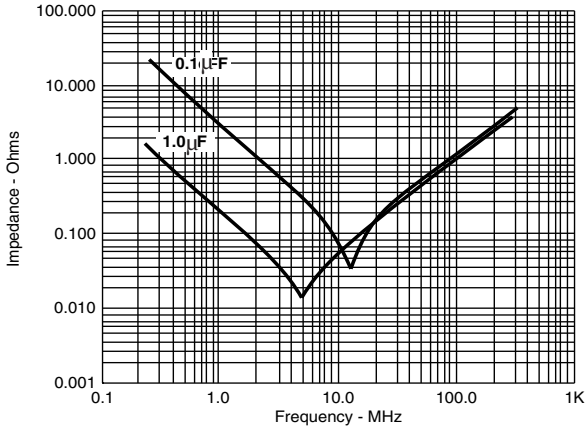
Impedance vs. Frequency



Impedance vs. Frequency for COG Dielectric



Impedance vs. Frequency for X7R Dielectric



Impedance vs. Frequency for Z5U Dielectric